The mobile revolution—using smartphone apps to prevent cardiovascular disease

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The mobile revolution – can smartphone apps help prevent cardiovascular disease?

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ABSTRACT

Cardiovascular disease (CVD) is the leading cause of death and disability globally. Mobile technology may be a potential solution to increase access to effective prevention. Given the high penetration of smartphones into groups with low socioeconomic status, health-related mobile applications (apps) may provide an opportunity to overcome traditional barriers to access and level the playing field across the CVD life course. The explosion of low-cost health-related apps that are not regulated raises three key areas of interest: firstly are apps based on evidenced-based guidelines or even loosely based on evidence at all; secondly, what evidence is there that apps are of benefit to people with CVD; and thirdly what are the components of apps that are likely to facilitate behaviour change. The purpose of this article is to review the current literature and the content of existing apps largely targeting facilitation of behaviour change for people with a medical condition, e.g. gamification, reward systems, personalisation. This paper will also present an overview of the current literature on mobile technology as it relates to prevention and management of CVD and evaluate the scope of prevention apps across the CVD life course and suggest opportunities to use these apps for primordial, primary and secondary CVD prevention.

INTRODUCTION

Cardiovascular disease (CVD) is the leading cause of death and disability globally, with the majority of CVD deaths occurring in low- and middle-income countries.[1]

Lifestyle risk factors are responsible for approximately 80% of coronary heart disease (CHD) and cerebrovascular disease globally.[2]. These risk factors include smoking, unhealthy diet and physical inactivity.[2] Low socioeconomic status is also an independent risk factor for CVD, though it tracks with many of the conventional risk factors.[2] Similarly, favourable CVD risk factor profiles are known to decrease morbidity, mortality, and improve quality of life.[3] Importantly, reduction of CVD risk factors at a population level has accounted for around half of the reduction in CHD deaths in high-income countries.[4, 5]

Secondary prevention explains the remainder of CHD death reduction, that is, improvement in risk factors at the individual level, including use of effective cardioprotective medications.[4] Secondary prevention programs, often termed cardiac rehabilitation, reduce risk of recurrent events through targeted risk factor reduction, including dietary and physical activity components, smoking cessation, medication adherence strategies, and psychosocial support.[6, 7] While the majority of these programs are typically hospital-based, time-limited, and contain supervised exercise,[8] compelling evidence suggests those which are conducted at home,[9] via telephone or Internet,[10] or in primary health care[11] are as effective at lowering CVD risk as more traditionally structured programs. Despite strong evidence for benefits of secondary prevention, access and participation in secondary prevention programs is suboptimal, with participation rates of only 15-30%.[12, 13] There are multiple reasons for low participation in supervised programs including geographical distance to the centre, unwillingness or embarrassment about group participation, lack of parking at the facility, return to work, and language barriers.[14] Of even greater concern, secondary prevention programs are only available in two-thirds of the 40 low- and middle-income countries responding to a recent survey about access.[15] Reported barriers to accessing secondary prevention programs are the same across low-, middle- and high-income countries.[15]

Mobile technology may be a potential solution to increase access to CVD prevention. Worldwide almost two billion people, equating to approximately 28% of the population, currently own and use smartphones. This is a 25% increase since

2013.[16] Rapid growth in technology has led to predictions that more than 50% of people globally will own a smartphone by 2018.[16] A digital divide still exists between socioeconomic groups, where people of lower socioeconomic status have older technologies, such as mobile phones which are only short message service (SMS) capable, and therefore do not have apps. However, access to smartphones appears to be influenced much more by age, gender and employment status.[17] Furthermore, in low- and middle-income countries mobile phones are estimated to reach 79% of the population, although smartphone ownership is currently low.[18] Smartphone ownership is predicted to rise rapidly in low and middle income countries,[19] potentially enabling these countries to bypass traditional barriers., Therefore traditional infrastructure, for example where face-to-face intervention or a clinic was previously the only way to deliver health care, may not be required..[20] Given the high penetration of smartphones into groups with low socioeconomic status, who have the double jeopardy of low access to medical care[21] and low socioeconomic status as a powerful cardiovascular risk factor,[22] health-related apps may provide an opportunity to overcome traditional barriers to access and level the playing field across the CVD life course, from primordial and primary, to secondary prevention.

Data from United States nationwide online and telephone surveys suggest that over half of all smartphone users access health-related information from their phone, and 19% have downloaded a health-related app.[23] Health-related apps are largely unregulated.[24] More than 43,000 health and fitness related apps exist in iTunes store alone, which have been downloaded over 660 million times.[25] However, over half the apps are downloaded less than 550 times,[25] demonstrating low uptake of the majority of apps. However, five apps account for 15% of all downloads, with the other apps falling somewhere along the continuum.[25]

The explosion of unregulated low-cost health-related apps raises three key questions of interest: first, are apps based on evidenced-based guidelines or even loosely based on evidence at all? Second, what evidence is there that apps benefit people with CVD, or prevent CVD in those currently disease free? Third, what components of apps are likely to facilitate behaviour change? The purpose of this review is to

present an overview of current literature on mobile technology as it relates to prevention and management of CVD, and explore the content of existing apps which aim to facilitate behaviour change for people with CVD.

Definition of an app

The term “app” is an abbreviation of the term mobile ‘application’, and refers specifically to a computer program/software designed to operate on a smartphone, tablet, or other mobile device.[26] Apps generally have limited functionality, compared to full websites, and are usually available to download through application distribution platforms including Apple iTunes apps store, and Google Play.[26] A distinction exists between native apps- those which are built using the device software and can maximise the features of the device, and mobile-enabled web apps- those which are built using browser software and have to be operated through the browser and are therefore dependent on Internet connection.[26] A number of app stores exist, but Apple has 80% of market share for app downloads.[27] While almost all smartphone users have downloaded at least one app,[23] most users globally exceed 20 apps on their devices.[28] The most frequently downloaded apps in 2013 were used for social media, gaming, or functional purposes (e.g. flashlight and maps).[29] Although over 90% of downloaded apps are free, selling apps is a multibillion dollar industry, with revenues exceeding USD$26 billion dollars in 2013.[30]

Regulation of apps

Apps are largely unregulated; currently the United States Food and Drug Administration (FDA) only regulates apps that are companions to moderate and high risk medical devices, for example blood glucose and blood pressure monitors.[24] The situation is similar in Australia, through the Therapeutic Goods Administration[31] and Europe through the Medical Devices Directive.[27] The FDA has to-date approved more than 75 medical apps, with functionality ranging from diabetes management, to electrocardiograph recording. Although app developers are encouraged to seek guidance from the FDA, approval is not mandatory.[24]

Lack of regulation in the app industry has allowed the emergence of unhealthy promotion messages within apps. A recent review determined there were 107 pro-smoking apps available, and these were downloaded by more than 6 million users.[32] These apps contain information about smoking, share images of favourite cigarette brands, provide smoking simulation, and advocate smoking.[32] The food industry also has been called to account for emergence of so-called 'advergames' where the product under promotion is a reward, or goal, for a character in the game.[33] App developers have a responsibility to adhere to truth-in-advertising and data privacy laws regulated in the USA by the Federal Trade Commission's Bureau of Consumer Protection, particularly as apps can collect significant amounts of demographic data that could be passed on to advertisers or third parties.[33] One app developer was recently fined USD$800,000 for inappropriate data sharing.[33] Although data sharing is illegal, in practice this may be hard to enforce.

Health-related apps

Although a cursory search of the iTunes app store in August 2014 revealed there were over 43,000 apps listed in the health and fitness category, an exhaustive review of these by IMS Institute for Health Informatics revealed almost half of these apps are misclassified, or only have loose connections to health and fitness.[25] The quality of apps and their purpose vary enormously, with the majority established simply to provide information, with no interactive capabilities.[25] Around two-thirds of health-related apps are aimed at consumers, and the remaining third at health professionals.[25] The authors of the IMS review developed a functionality rating score, with a scale between 0 (for low functionality) to 100 (for excellent functionality).[25] The criteria underpinning the IMS scoring system included type and quantity of information provided, how data is tracked or captured, communication processes and quantity of device capabilities.[25] The average score received by 16,275 apps reviewed was only 40,[25] showing the low overall quality of the majority of health- and fitness-related apps..

While the IMS review looked exclusively at apps available in the US iTunes store, not all healthcare apps are widely available through application distribution platforms. Some apps are available only by medical prescription,[25] which in practice can make it hard to find the most appropriate app. For example, Bluestar (a diabetes tracker app) received FDA approval in 2013, and became the world's first prescription-only app.[34] This highlights another potential barrier to finding appropriate apps, since they may not be publically listed.

Evidence for health-related apps

Health-related apps are now being described as an integral part of current medical practice, for their potential to both improve efficiencies, and overcome barriers of distance to service providers.[35] What is still under debate is the ability of apps to genuinely improve health behaviours long term,[36] especially as current literature highlights the overall poor quality and lack of evidence-base of available apps.[36-40] The literature is also conflicting on the credibility and quality of information of paid versus free apps. Two reviews concluded information within paid apps is overall more credible and trustworthy; likely to be of a standard that can be recommended by health professionals; and developed with a specific aim of health promotion and/or disease prevention.[39, 41] In contrast, a review of weight loss apps found no difference in credibility or content in paid compared to free apps.[42]

Some apps have been developed according to evidence-based guidelines, and have demonstrated real benefit improving clinical outcomes. One example is 'WellDoc diabetes management program',[43] originally developed and tested in a randomised controlled trial in 2008. This system provides real-time feedback on blood glucose levels in individuals with Type 2 diabetes, displays medication regimens, incorporates treatment algorithms and communicates directly with patients' health care providers.[43] Upon completing the program, participants in the intervention arm had a significant decrease of over 2% in their Haemoglobin A1c levels compared to 0.68% in controls.[43] The success of this program led to USD$500,000 venture capital funding in 2012,[44] and following this USD$20 million funding from Merck Global

Health Innovation Fund in 2014.[45] Commercial investment is important, because development of an FDA-approved class 2 medical device is estimated to cost USD$24 million dollars,[44] in large part due to very high costs of carrying out randomised controlled trials.

While the success of WellDoc is encouraging, a recent review of pain apps found translation of evidence into practice is not happening readily, as the apps tested by researchers are not made commercially available; commercially available apps have limited evidence to support their use.[37] Experts suggest that evidence-based apps will increasingly become commercially available.[37] However, challenges remain for people choosing apps as they struggle to identify which have scientific merit and are effective.

A major limitation is the length of time research takes relative to the release of new apps. A typical research project must develop the intervention and study design (~6-12 months), apply for funding (~12 months), seek ethics approval (~6 months), recruit patients and follow them up (~24 months), analyse data (~6 months), and then publish the results (~6-8 months). A conservative estimate suggests this process takes around five years, although translation of research into practice takes up to 17 years.[46] Meanwhile, there are 1.3 million apps in the app store,[47] with 20,000 new apps added every month.[48] By the time researchers have determined the clinical benefit of an app, technology has evolved; the app being studied may well be superseded by new developments (Figure 1). **Evidence for apps in cardiovascular disease**

Evidence that apps will improve cardiovascular health is currently limited. In 2013, a review of cardiology apps found 710 apps,[49] of which the majority were heart monitors and medical calculators, with very few apps specifically targeting cardiac rehabilitation or prevention.[49] Our own review identified clinical trial protocols for four studies which use apps to directly target cardiovascular risk factor reduction.[50-53] Additional papers focused on web-based applications were identified, but these were excluded if a companion app was not available to enable their use on smartphones

or tablets; if the predominant purpose of the trial was testing monitoring devices (e.g. sphygmomanometers); or the purpose of the app was to facilitate transfer of data.

Of the four identified protocols for cardiovascular risk reduction only one app, known as the 'Care Assessment Platform,' has published results.[54] This was a randomised controlled trial of traditional cardiac rehabilitation compared to an intervention group using a smartphone cardiac rehabilitation app providing daily SMS messages, multimedia education topics, relaxation audio files, and a light to moderate physical activity program. Participants were able to set and monitor goals and the app included a step counter and exercise diary.[53] Trial results demonstrated uptake of cardiac rehabilitation was much higher in the intervention group.[54] Importantly, the intervention group had significantly higher adherence and completion than the traditional cardiac rehabilitation group. Both the intervention group and traditional cardiac rehabilitation group significantly improved their 6-minute walk test distance (improvement of 60m and 47m respectively), emotional state, and quality of life; and lost non-significant amounts of weight.[54] The study demonstrated a smartphone app can achieve equivalent improvements in secondary prevention outcomes as traditional cardiac rehabilitation, and significantly better at recruitment and retention.[54] This is important when we consider the low global uptake and retention for cardiac rehabilitation. However, despite the promising findings of the Care Assessment Platform, there is no research to determine if there are any long-term benefits of using apps to promote health.

Core components and ideal features for health apps

Persuasive technology utilises convincing communication to increase behaviour change.[55] Importantly, persuasive technology is modelled on ideas that behaviour change only occurs when people have sufficient motivation, ability, and appropriate triggers to undertake change.[55] Behaviour change is most likely to happen when a number of core components and ideal features are present within the app. Features which were identified in this literature review as necessary to support behaviour change in CVD were documented and a list was refined iteratively to develop a set of

core components. These include availability of a privacy policy, evidence that information is provided from reliable and credible sources, and evidence the app is based on behaviour change theory. Specific features that value-add to apps include personalisation, real-time tracking of biometric data, gamification to enhance interactivity, use of positive rewards, opportunities for engagement with others (social elements), and simple and clear presentation of content. Taken together these elements are those which are most likely to increase the longevity of the app. Each of these aspects are discussed in more detail below.

Privacy policy

Only 30% of mobile health apps have privacy policies, and these are generally written in complex language, requiring high literacy levels.[56] Health apps may collect large amounts of personal data, therefore app developers need to take measures to ensure they do not sell consumer information (e.g. to advertisers),[57] especially as many free apps make their money from advertising.[58] Privacy concerns are a major barrier to uptake of health-related apps, not only in relation to data sharing, but also in terms of personal safety. For example, GPS tracking might enable identification of times when the user is away from home.[59] Checking that a privacy policy exists and that it provides adequate protection for the user's data is an important component of mobile app use. *Credible source of information*

Knowing information comes from a credible source is highly ranked by consumers.[60-62] The credibility of both who develops, and who recommends the app is important. Patients rate recommendation by their physician very highly,[14] underscoring the importance of health care professionals having sufficient information to recommend apps that are evidence-based and adhere to reasonable principles.

Behaviour change theories underpinning the app

Behaviour change is complex, and must be sustained to be successful.[63] Positive behaviour change is enhanced when people are actively engaged in decision-making,[64] a potential strength of mobile apps. A number of papers highlight importance of behaviour change theory underpinning app content,[65-67] but there is

lack of behaviour change theory underpinning development.[68] A recent review of behaviour change techniques in physical activity apps revealed the majority did not successfully incorporate behaviour change theory in their design.[69] In physical activity apps the most common feature to promote change is an educational component, with instruction on how to complete a task.[69] In one study, three behaviour change techniques were tested by creating three different apps each underpinned by theoretical models, to determine which increased physical activity the most.[62] The theories tested included social cognitive theory, social influence theory, and operant conditioning. All three apps facilitated behaviour change, with operant conditioning considered least effective.[70]

Personalisation

Personalised information is a central component of successful behaviour change.[61] The ability to adapt content to the user, enable setting of personal goals, and tailor information and rewards relative to the individual, all increase perceived benefits of an app.[71] Of course, the more apps are personalised, the more personal data they will store, making privacy policies of even greater relevance.[72] One way which an app might access personalised information is through cloud-based data sharing, seamlessly connecting patients' electronic medical records with the app,[73] although of course this raises security issues for personal data.

Real-time tracking of biometric data

One feature to increase engagement is the ability to track biometric data in real-time, a feature very highly regarded by users of apps.[59] Studies have found self-monitoring is likely to increase behaviour change.[60] Importantly, timely self-monitoring of behaviour is an important component of behaviour change.[74]

Gamification

Gamification is the use of video game elements in non-gaming systems to improve user experience and user engagement.[75] In the health context gamification helps to

incentivise lifestyle changes, keeps people engaged for longer, makes goals tangible, increases anticipation, and gives rewards for goal achievement (Figure 2).[75]

Rewards

Providing contingent rewards is another important component of behaviour change.[74] The benefit of providing rewards is recognised as central by retailers, with apps now targeting shoppers in store with tailored rewards to increase spending.[77] However, a review of physical activity and dietary apps found only 25% of apps used rewards as a component of their software.[78] Another advantage of app-based rewards is they increase loyalty.[79] Devotion is important because CVD prevention apps need to be used over long periods of time to promote lifelong behaviour change. Rewards can be simple, such as positioning on levels and leaderboards (information displaying relative ranking among competitors) .[79]

Social elements

Opportunities for social comparison and social support are important to increase behaviour change.[74, 80] The website, “PatientsLikeMe”, is specifically developed for patients to engage with others with the same condition,[81] a very popular way for people to connect with others and rate their own health or experience against others. In one qualitative study, people deemed an element of competition would help achieve their health goals, whereas others considered tips and advice from people with similar goals of potential value.[59] Being able to make contact with health professionals is highly rated.[59, 80] Health professional advice has been more clearly demonstrated in apps with specific biofeedback purposes,[82] there is potential for this to be extended to preventive apps.

Simplicity and clear visual presentation

Simplicity seems to be one of the most important features in acceptance and usage of health related apps.[83, 84] Importantly, the choices must be clear and unambiguous, and there must be a minimum number of steps to complete tasks.[85] Above all, the information presented must be clear and concise.[85]**Tools for evaluating apps**

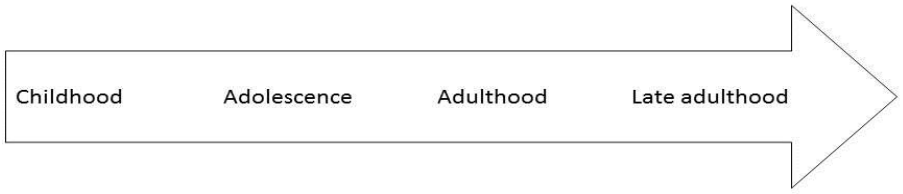
It is clear evaluating apps for CVD is highly complex. A number of sites exist for sourcing and evaluating health apps, such as My Health Apps,[86] Happtique,[87] the NHS choices health apps library,[88] and iMedical Apps.[89] These evaluation sites aim to provide ranking of apps, and evaluate the content to ensure it meets some level of acceptable standard. But even for these sites, the process of evaluation is difficult; for example, Happtique launched a certification process for health-related apps, which had potential to make credible apps easy to identify, but, this was ceased in early 2014 after a number of certified apps were found to have several security flaws.[90] These security flaws included data sent and stored in plain text, and passwords and usernames stored in plain text.

Despite these concerns, these sites for evaluating apps provide opportunities for user-based rankings, classification of apps and content, expert review and potential for certification processes. However, these sites will require an increased range of apps and further development before they are of benefit. There is also potential for conflict of interest if provision of a high ranking or recommendations of certain apps favour particular companies, developers or experts, or if health professionals are incentivised to refer patients to certain apps

Opportunities for using apps for CVD prevention throughout the life course

Numerous opportunities exist to use apps for CVD prevention throughout the life course, and different features are likely to have more importance at different stages. Through our review of the literature, we determined some features that were more appealing at different stages of the life course. We refined this iteratively and determined through consensus the importance of apps and likely appeal of different features across the life course (Table 1). Modification, or prevention, of CVD risk factors is demonstrated to reduce morbidity and mortality.[91,92] These risk factors are cumulative in their deleterious effects, and modern risk reduction guidelines focus on comprehensive risk reduction, using absolute CVD risk calculators, rather individual risk factor reduction.[91, 93]

Table 1: Importance of apps and likely appeal of different features across the life course



CVD Prevention & Management Across the Lifespan	Primordial (environmental, economic, social, behavioural and cultural actions)		Primary & Secondary (risk factor reduction and management)	
Example areas of impact for health-related Apps	• Promotion of fruit and vegetable intake at home • Prenatal smoking cessation	• Anti-tobacco program to reduce uptake of behaviour • Physical activity • Healthier diets • Mental health	• Smoking cessation • Weight loss/control • Hypertension or other risk factor management • Physical activity	• Healthier food choices • Medication adherence • Mental health
App Features				
Gaming principles	+++	+++	+++	++
Rewards	+++	+++	+++	+
Credible source of information	-	+	+++	+++
Credible referrer	-	+	+++	+++
Personalisation	+	++	+++	++
Self-monitoring or tracking	-	+	++	++
Contact with health professionals	-	+	++	++
Social comparison & social support	+	+++	++	+
Simplicity & clarity of screen use & tasks	+++	++	++	+++

Privacy	-	+	+++	+++
Concise information	-	+	++	+++
Simple data download	-	++	++	+++

Key: feature is not relevant to the target audience -, feature is of low importance to target audience +, feature is of moderate importance to target audience ++, feature is of high importance to the target audience +++

Primordial prevention

Primordial prevention focuses on establishing healthy living patterns to prevent the emergence of risk factors. It includes environmental, economic, social, behavioural or cultural actions which seek to minimise the potential for development of CVD risk factors.[94] Examples of primordial prevention include: targeted tobacco control programs for non-smokers at vulnerable times when they might adopt smoking behaviours, in childhood or adolescence;[95] and targeted dietary intervention in school age children to increase fruit and vegetable consumption in the home.[96] Children are increasingly eating calorie dense diets,[97] spending insufficient time performing moderate to vigorous physical activity,[98] and exceeding the recommended hours of screen time with resultant sedentary behaviour.[99] These unhealthy behaviours are likely to be sustained if established in childhood.[100] While increased screen time is part of the problem, it has potential to be part of the solution, for example, through use of active games which increase physical activity.[101]

Mobile device use is high in children, with a five-fold increase in ownership of tablet devices observed between 2011-13.[102] Furthermore, three-quarters of children under eight years have access to either smartphones or tablets at home.[102] Although there is a wide gap between socioeconomic groups in terms of device access and ownership, the gap has diminished substantially over the last two years.[102] Eighty percent of parents in the high-income bracket have downloaded apps for their children, while only 31% of parents in low-income brackets have downloaded apps

for their children.[102] There is also the potential to use apps to help parents to faciliate behaviour change in children.

The use of mobile devices increases into adolescence, with almost 80% of teenagers having their own mobile phone, and half of these are smartphones.[103] At least half of the teens with a smartphone access the Internet predominantly through the smartphone, rather than any other digital device.[103]

Teenagers use apps for social media or gaming.[104] A recent survey of 7000 American teenagers revealed social media apps as the most popular apps, with Facebook and YouTube the most highly utilised.[104] However, gaming apps constitute a large portion of time spent online. Seventy percent of the UK population have accessed a gaming app via their smartphone, with females of all ages now gaming more than males.[105] This is thought to be because apps available on smartphone make gaming much more attractive and non-threatening for females, with apps such as Words With Friends and Candy Crush Saga being particularly popular.[105] Utilising principles of social connectivity could potentially benefit younger people. For example, the use of an app which encourages people to make healthier food choices by comparing food intake (Figure 3), or by tracking run distances and comparing routes, times taken, and duration of activity (e.g. MyFitnessPal, or Strava).

Primary prevention

Once CVD risk factors have emerged, primary prevention becomes important. Some interventions are considered both primordial and primary, for example smoking cessation programs for pregnant mothers are primary prevention for the mothers, and primordial for the fetus.[107] A further example would be interventions to decrease dietary sodium.[107] Primary prevention interventions specifically target known CVD risk factors, for example, smoking cessation programs, weight loss programs, or hypertension management programs[107]

The range of apps considered suitable for primary prevention is vast. Anything from blood pressure trackers (e.g. Blood Pressure Log), quit smoking apps (e.g. QuitSTART), weight loss (e.g. Weight Watchers), to fitness and walking trackers (e.g. MyFitnessPal), could fit in this category. Once again the consumer is faced with overwhelming choices, and, of the top 100 grossing health and fitness apps, there is little to suggest they are underpinned by scientific evidence.[108] Furthermore, highest ranked apps are not necessarily those with the best evidence. However, exceptions do exist.

One recent primary prevention initiative has been the development of the 'FoodSwitch' app (Figure 4). This app uses the smartphone camera to scan barcodes of around 90% of foods available in Australian supermarkets, and makes healthier suggestions based on fat, saturated fat, sugar, salt and overall energy content.[109] An easy traffic light system makes food choices simple. The app developers use a crowdsourcing approach to continuously update the list of foods available in their database.[109]

Secondary prevention

Efforts to reduce CVD risk factors in individuals who have existing CVD is termed secondary prevention.[110] Risk factor management is known to be of great importance in preventing recurrent CVD events, decreasing mortality, and improving quality of life.[9, 11] International guidelines recommend participation in comprehensive secondary prevention programs after a cardiac event.[111-113] Despite strong evidence

and guidelines recommending participation, referral, enrolment, and completion of such programs is typically low, with only 15-30% of eligible people participating.[12, 13] The 'Care Assessment Platform' results provide encouraging evidence that smartphone apps might increase participation and completion of secondary prevention programs.[54] These results highlight that a combined approach for secondary prevention using face-to-face and app-based models may produce greatest benefits. But while only one app specifically designed for secondary prevention of CVD has been formally evaluated, there are others available. The National Heart Foundations are reliable sources of quality information about CVD. In Australia, the Heart Foundation has developed the My heart, my life app (Figure 5).[114] This app allows individuals to track medication, personal health stats, search for recipes, and find information and videos on warning signs of heart attack. Similarly, the British Heart Foundation has developed a recipe finder app, with all recipes checked for nutritional content by British Heart Foundation dietitians.[115] The Canadian Heart and Stroke Foundation has also developed a 30-day challenge app, where the user sets goals to reduce CVD risk.[116]One potential concern with apps for secondary prevention is people are generally older by the time they develop CVD, and mobile technology has been less widely adopted by older people.[117] In 2013, only 18% of people over 65 years old owned a smartphone, compared to 56% of people overall.[118] However, a Deloitte report predicts ownership will increase to 50% by the end of 2014, with over 65's being the fastest growing market for smartphones.[119]

Age itself is not a barrier for app usage, and apps have been successfully used in the older population to improve physical activity,[120] and cognitive function.[121] However, despite growth of smartphone usage by people over 65 years, a recent report highlights an area of inequality; at least 25% of older smartphone users have never downloaded an app to their device.[119] Challenges of complex data usage plans, and apps which are not developed for those with declining vision, decrease the likelihood of apps being downloaded and used by older adults.[119] Some smartphones may even be too small for the older user to hold, and there are challenges associated with small buttons, which may be particularly difficult for those

with tremor or poor vision.[122] Notably for app development, the older people are, the less they are willing to take a trial-and-error approach to new apps, with older people preferring to have a user manual to refer to.[123]

Opportunities for using apps for CVD prevention in low- and middle- income countries

Research of mobile phone use to improve health in low- and middle- income countries has been dominated by the use of SMS messages, due to the low penetration of smartphone technology.[20] However, it is predicted that smartphone use will rapidly rise in low- and middle-income countries,[19] and use of apps to improve health may be a way that the gap in healthcare provision between high-, low- and middle-income countries could be closed.[20]

CONCLUSIONS

Although some apps are based on evidence-based guidelines, the complexity of selecting and evaluating an app remains challenging. Future efforts should involve clearer labelling of apps, improved cataloguing in app distribution platforms, and increased content in app evaluation sites. Consumers face an overwhelming level of choice, and many apps may be poorly designed, have no basis in evidence, and become rapidly outdated. However, apps are potentially much easier than print material to refresh. Evaluation of apps is complex, and evaluation sites, such as the NHS health apps library, have potential to help consumers make an informed choice, and should be more widely promulgated by health professionals.

Preliminary trials indicate that apps have potential to benefit people with CVD, However, data is limited and long-term outcomes are not yet available. Regulation of CVD prevention apps would be of enormous benefit, but is unlikely to occur due to the sheer volume of apps available.

To be of greatest benefit, CVD prevention apps should have an adequate privacy policy, be grounded in behaviour change theory, and information should come from a credible source. The components most likely to be of benefit are personalisation,

gamification, rewards, social elements and simple and clear presentation. However, more research is needed to examine these features together with the potential for new aspects that may currently be undeveloped.

For future success, app developers should work together with health care professionals and researchers to deliver evidence-based apps which improve healthcare outcomes. An overhaul of research process to reduce delays would help to ensure app-based CVD prevention research is not entirely left behind by advances in technology.

KEY POINTS

- Identification of suitable apps is complex; cataloguing of apps needs to improve
- Regulation of apps is limited, therefore finding credible sources is of high importance
- Smartphone penetration is high in high-income countries and predicted to rise in low- and middle-income countries.
- Apps have the potential to reduce inequalities in CVD prevention, though some challenges remain in elderly users
- Opportunities exist to use apps for CVD prevention throughout the life course
- The length of time it takes to research apps means that the app may have been superseded by the time the results of the study are published

REVIEW CRITERIA

The references included in this article were selected by searching PubMed, google scholar and Scopus in August 2014 using the following search terms: apps, ehealth, telehealth, telemedicine, computers, handheld, mobile, mobile applications, smartphone, cardiac, cardiovascular, cardiovascular diseases. The reviewed apps were selected by searching for apps with search terms heart, cardiac, rehabilitation, and prevention in the Apple iTunes store and Google Play Store.

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AUTHOR CONTRIBUTIONS

LN, NL and GC researched data for the article. LN undertook initial drafting of the manuscript. All authors contributed to critical revision of the manuscript for important intellectual content; and provided final approval of the version to be published.

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